

Cloud properties and transitions in MAGIC simulated by a mesoscale model

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Introduction

The MAGIC field campaign, conducted by the DOE Atmospheric Radiation Measurement (ARM) program in 2012 and 2013, provided comprehensive measurements of atmospheric properties over the northeast Pacific, emphasizing cloud properties in diverse regimes and the transitions between them. We use these data to evaluate simulations with a mesoscale model, WRF, in a quasi-operational configuration.

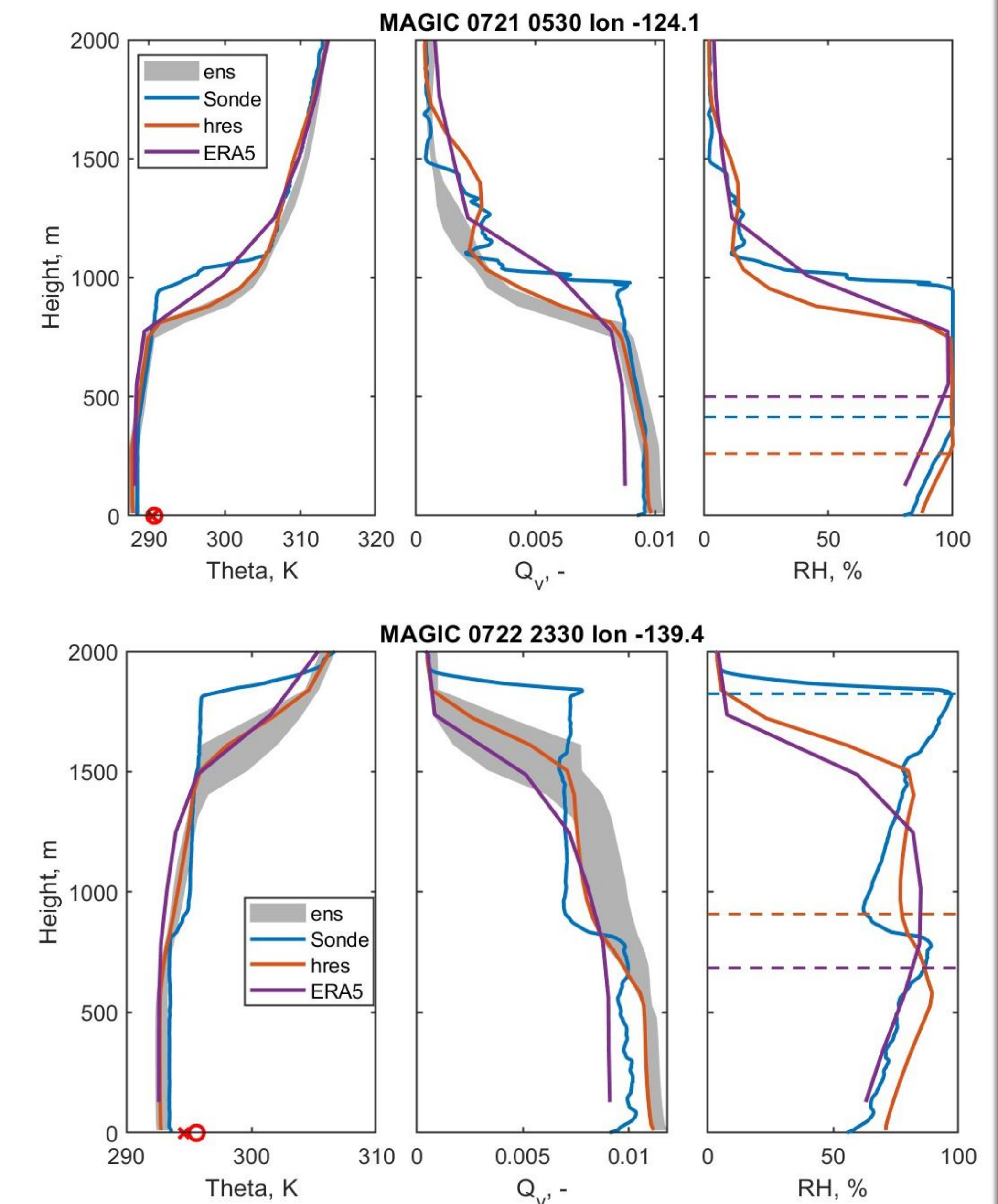
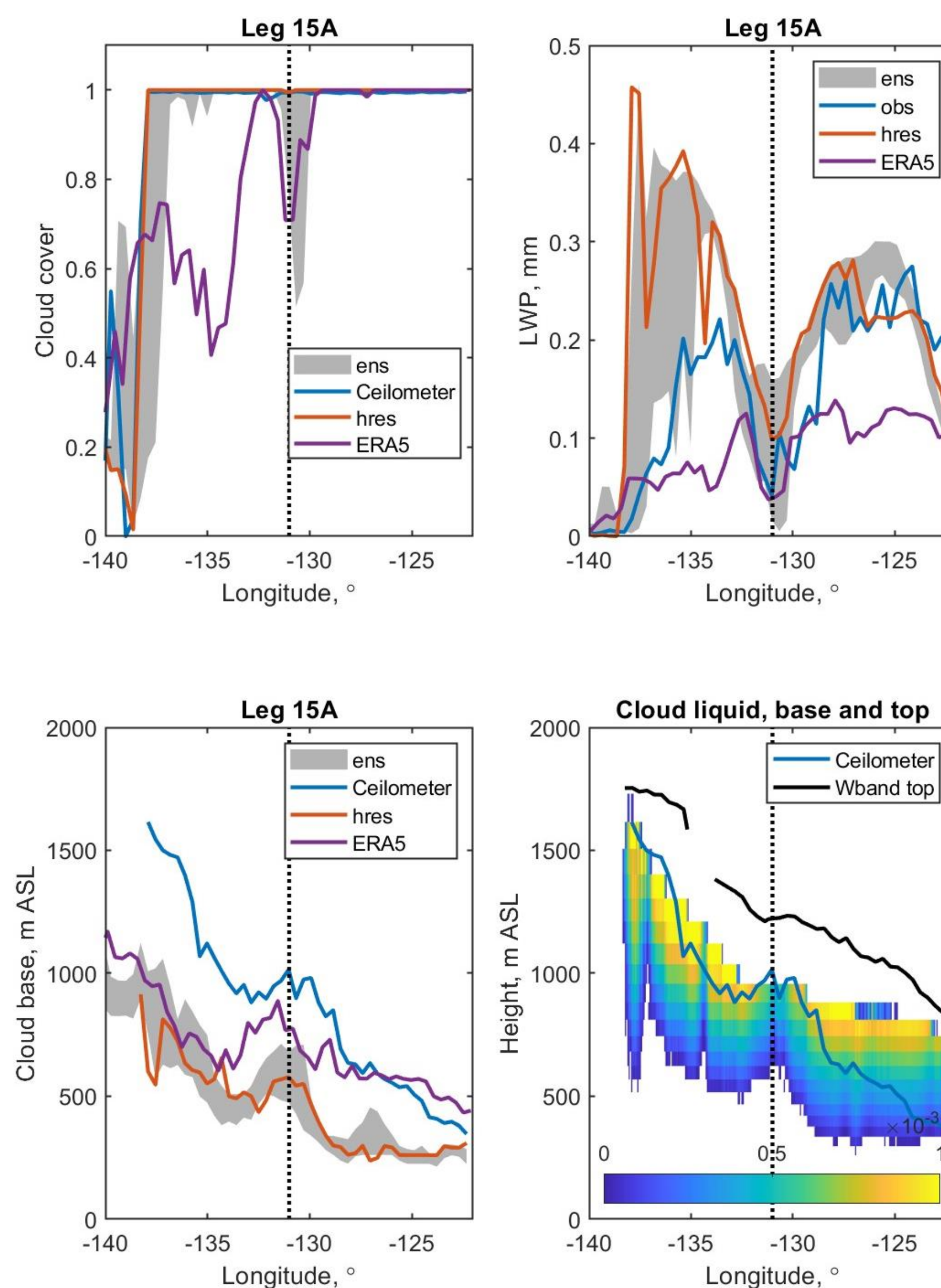
WRF v4.5 is initialized from the ERA5 reanalysis and run on a 13-km grid. The configuration mimics the operational RAP/HRRR, using the MYNN-EDMF PBL and shallow cloud scheme, Thompson microphysics, Grell-Freitas deep (only) convection, and RRTMG radiation.

A 115-level vertical grid derived from the lower levels of the GFS grid is used. This grid has approximately 100-m spacing in the cloud layers. Other level sets produced somewhat different results, not shown here.

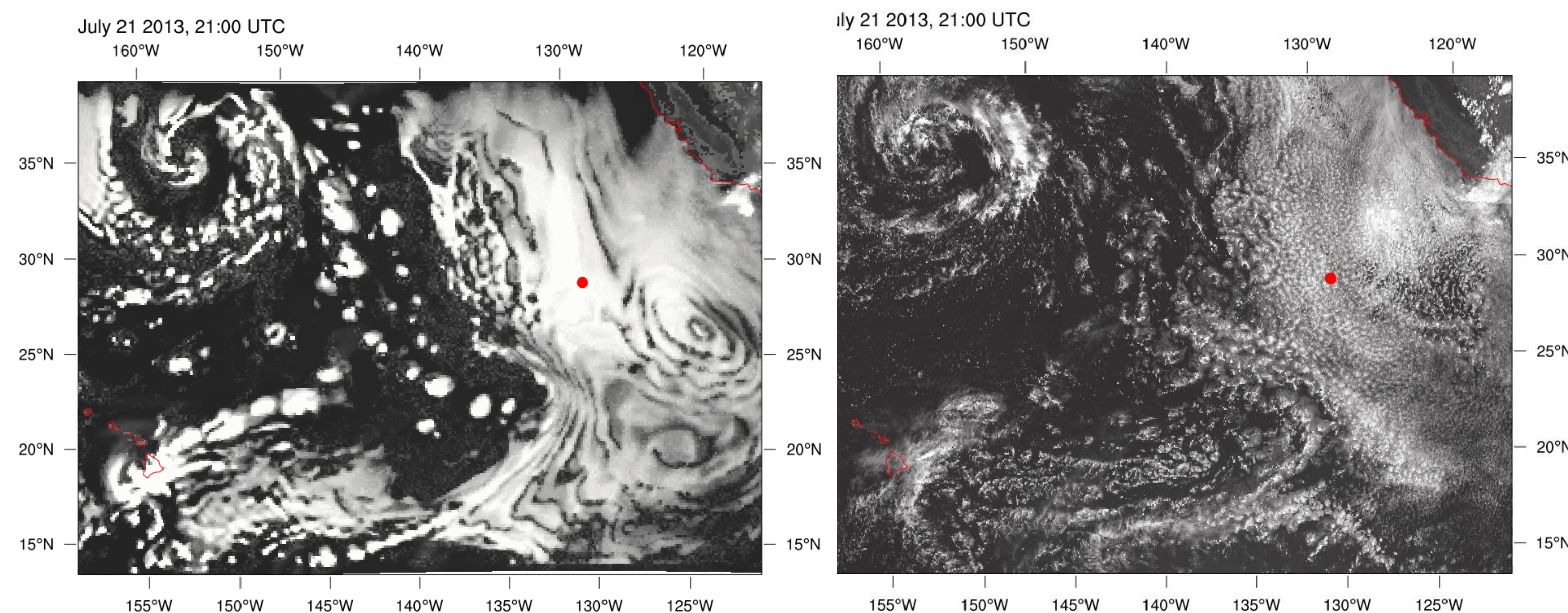
The ship equipped with the ARM Mobile Facility made many trips between Los Angeles and Honolulu. Leg 15A (20-25 July 2013, east to west) is the “golden” leg used in many studies.

Stratocumulus regime and transition

Cloud properties are well simulated in stratocumulus and up to the transition, except that cloud base is too low. Transition timing is excellent. ERA5 is biased dry.

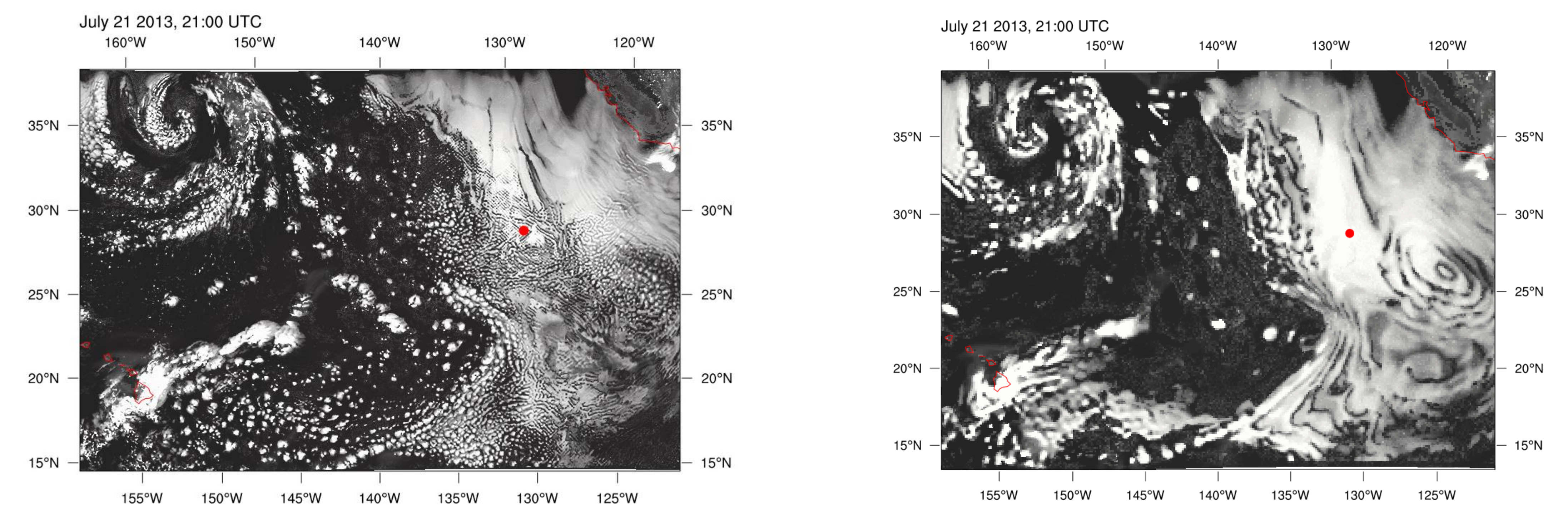


Real and simulated satellite images



Simulated and actual satellite views of the domain at 2100 UTC 21 July. a) Simulated shortwave radiation upward at the top of the atmosphere. b) Visual image from GOES.

Improving structure



13-km simulation produced “blobby” clouds, which result from partially-resolved circulations. Using a 3-km grid (left) produces better cloud structure (compare to satellite image in the box to the left). Making a “minor” change to the MYNN-EDMF scheme (right) to allow larger and stronger updrafts in regions with a smaller sensible/latent heat flux ratio converts some of the blobby clouds to subgrid clouds, also a better match to the observed cloud field.

Conclusions

- Stratocumulus and transition are very well simulated by this WRFv4.5 configuration
- Some remaining flaws are due to the ERA5 reanalysis used for initialization
- Cumulus regime is difficult to evaluate because of poor sampling
- Cloud structures in cumulus region are too large because the circulations are only partially resolved
- Structure can be improved by using a finer grid or by increasing the strength of the updrafts within the EDMF scheme